INTERCANINE DISTANCE IN THE ANALYSIS OF BITE MARKS: A COMPARISON OF HUMAN AND DOMESTIC DOG DENTAL ARCHES

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ABSTRACT

One common parameter considered helpful to identify the origin of bite wounds has been the distance between the canine teeth marks left on the victim. The reliability of this parameter to differentiate the origin of the marks (human or animal) was evaluated using a sample of: a) domestic dogs (n=50) weighting between 4.9 kg and 46 kg of undefined breed and b) human beings (n=50). Dog intercanine distances (ID) were measured directly using calipers, those from the human sample were measured from wax imprints using calipers. It was found that dog bite intercanine distance measurements were overall 2.8% wider for the upper arch and 10.4% wider for the lower arch when compared with the overall result for humans. However, it was observed that the measured values for medium sized dogs (between 9.1 kg and 23.0 kg) are similar to the overall results for humans. Therefore, for this range, the stand alone use of intercanine distance measurements from bite wounds marks are inconclusive with respect of defining if of human origin.

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Keywords: Forensic dentistry; human bites, dogs/AH, identification.

Running title: Bite marks, intercanine distance, human and domestic dog dental arches.

INTRODUCTION

The lesions produced by bites are objects of forensic analysis and one of the first considerations is to determine their origin; whether they were produced by an animal or human. Depending on the outcome, the subsequent investigation will take an entirely different course.

Careful analysis of the dental characteristics and features of a bite mark may help identify whether the biting injury was self-inflicted, caused by an aggressor, an animal or at the very least, may exclude a suspect.[1,2] As soon as a bite mark is detected it should be examined by an expert to determine, among other factors, whether the size and configuration are within human parameters[3] and if there are enough details and preserved remains that reveal any distinguishing features of the dentition.[4,5] Consideration should also be given, for example, to the resistance of the tissue, the anatomical location, position of the bitten person. [6,7]

One of the parameters of the investigation is the measurement of the intercanine distance, as the impressions of the anterior teeth are usually the most evident and likely to be measurable.[8] Spencer[9] highlights the importance of careful measurement of intercanine distances during an investigation. Each injury should therefore be evaluated to determine whether it was produced by human or animal teeth[10] - a distinction that requires comparative knowledge of dental anatomy.[11] The distance between the upper canines in an adult can range from 25 to 40 mm. It has been suggested that a distance less than 25 mm may have been produced by a child,[12] but the recognition of deciduous tooth marks in the bite mark may be a better indicator. For adults in Brazil, the mean intercanine distances in the upper arches has been measured at 29.4 mm, and in the lower arches the mean is 26.7 mm.[5] Bites produced by dogs and other animals often cause much damage with tissue laceration and (avulsion) and human bites can include a wide range of injuries from bruising, abrasions, lacerations and ocassionally tissue avulsion.[13, 14]

The domestic dog (*Canis familiaris*) and humans have a notably distinct morphology of the teeth and arches. This fact may sometimes lead the researcher to believe that the difference between a human bite and one caused by a dog is not at all complex.

However, the movements that take place during the bite, along with particular aspects of the supporting tissue can lead to lesions inflicted by dogs that resemble those caused by humans.

Considering just domestic dogs, the intercanine distance may vary with the animal's breed and weight. This distance in the North American domestic dog ranges from 13.0 to 48.0 mm in the maxilla, while for the mandible there is a range of 6.0 to 49.0 mm.[15] Although there is awareness of this variation, there are no Brazilian studies that present tables of measurements in order to guide the differentiation of bites produced by dogs and those produced by human dentitions.

The head and neck are the most frequent sites of injury in victims bitten by dogs, and bites occasionally result in death. There are very few studies on injuries left by dog bites in humans.[16] However, it is an important topic, due to the fatal attacks by aggressive breeds of dogs; 85% of fatal cases occur in children under 12 years.[17] All types of dogs are capable of inflicting injury on people and the conclusive and objective determination of the breed of dog is only possible by examining the pedigree (potentially time-consuming and complicated) combined with DNA testing. Mixed breed dogs, or those that have not had their pedigree registered cannot be recognised as a certain breed and their description is usually vague and based on subjective visual observation.[18] More than 30 breeds of dogs were described as being responsible for fatal attacks on people in the United States from May 1975 to April 1980 and in many cases they were dogs of mixed origin or unknown breed.[19]

The masticatory force of dogs of different breeds varies with the excitement of the biting animal, and also with its weight.[20] The shape and size of the skull have been suggested as factors related to the variation in the size and position of the teeth.[16,20,21] It is important to consider that there is always the possibility of distortion, hindering or even making it impossible to physically analyse the bite mark[22] and that guidelines laid down by the forensic odontology community for such an analysis should be respected.[23]

Thus, to evaluate whether the intercanine distance is a reliable parameter to differentiate between bite marks produced by humans and domestic dogs, this distance was measured for the upper and lower arches in a sample of 50 domestic dogs of different weights and 50 human subjects. Knowledge of these characteristics may enable greater scientific certainty in establishing the differential diagnosis of bite marks; their study is an important area of forensic odontology and there is a lack of clear parameters for classification.

MATERIALS AND METHODS
The study used no. 7 pink wax plates, a heating lamp, plastic containers and a caliper for both the human and dog sample. The researchers also used personal protective equipment (PPE). A single examiner was responsible for carrying out all measurements and intra-examiner calibration was performed by successive measurements in predetermined scale (millimeter ruler) with no significant differences. The results were also evaluated by a second observer, resulting in agreement between them.

Human sample: The study sample consisted of 50 bite marks made by human subjects, young adults (students of the Faculty of Dentistry, University of São Paulo), of both genders, on plates of pink wax (no. 7). The decision was made not to distinguish this sample by gender or age, because such information is not initially obtained when evidence of bite marks is found. After explanation and justification of the objectives of this study, consent was obtained and consent forms signed, which allowed the use of the material (plates with bite mark impressions and the values obtained for the intercanine distance). The students were asked to bite into a wax plate that was folded in half and slightly softened by the heat of the lamp. The plates with the bite impression were placed in individual plastic envelopes and handled by the researchers, always with the use of personal protective equipment (PPE). Measurements were taken with a caliper, noting the distances in mm between the tips of the right and left canine (as measured in a straight line) imprinted in the wax plate in the maxilla and mandible

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separately, and the values were recorded on separate forms (Fig. 1).

Sample of domestic dogs: (*Canis familiaris*): The study sample consisted of 50 dogs with no restriction concerning breed, size or weight; they were attended to at the Laboratory of Comparative Dentistry, Faculty of Veterinary Medicine and Animal Science, University of São Paulo. With permission granted by those responsible for the dogs, measurements of the domestic dogs' intercanine distances were taken directly from the mouth using a caliper. During the study the animals were sedated, in preparation for scheduled procedures that were separate to our research. To calculate the amount of sedation required, animals were weighed beforehand and these data were also recorded. There was no removal of biological material, use of drugs or exposure to stress, pain, restriction of water or starvation due to this study, in accordance with ethical principles involving research with animals.
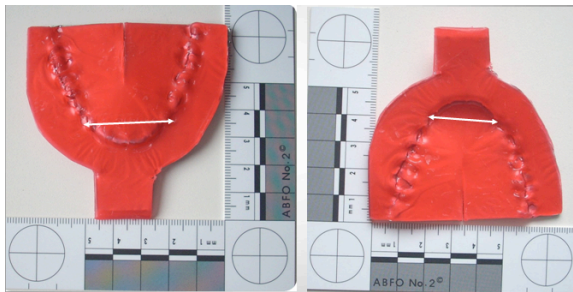

Fig. 1: *Human sample: measuring the distances in mm between the tips of the right and left canine imprinted in the wax plate, in the maxilla and mandible.*

The distinction by breed of dogs was not considered since the determination of a specific breed requires reliable methods that are not available to the general population. The animals in this sample were considered "no defined breed" (NDB). Due to the extensive range of sizes of the domestic dog found in nature or due to intervention by man in the selection of breeding, animals were divided according to their physical size, taking into consideration their weight in kilograms: small size (for animals with weight equal to or less than 9.0 kg), medium (for animals over 9.1 kg up to 23.0 kg), large size (for those weighing between 23.1 kg and 40.0 kg), and giant-sized (for animals over 40.1 kg),

according to the classification proposed by Goldston and Hoskins.[24] The measurements in millimeters of the distance between the cuspid tips of the right and left canine were considered, and were taken from the upper and lower arch using a caliper (Fig. 2).

Because this evaluation of the measurement of intercanine distances from humans and domestic dogs only used a caliper, there was no risk to the participants and the confidentiality of identity was preserved during the research. For the descriptive statistics of the sample, the statistical package BioEstat 4.0[25] was used, with a confidence level of 95%.

Fig. 2: *Domestic dog upper arch intercanine distance measurement (A to B).*

RESULTS

For the 50 dogs, the mean weight was 14.3 kg, with a standard deviation of 8.2. The lightest was 4.9 kg and the heaviest was 46.0 kg. In order to analyze the measurements of intercanine distances of the animals they were divided into four levels according to their physical size relative to body weight in kilograms: less than or equal to 9.0 kg (small), from 9.1 kg to 23.0 kg (medium), from 23.1 kg to 40.0 kg (large) and greater than 40.1 kg (giant). Fifty-eight percent (n = 29) of the animals were medium sized, with a mean weight of 13.8 kg, 28% (n = 14) were small with a mean weight of 7.3kg, 12% (n = 6) were large size, with a mean of 27.6 kg and only 2% (n = 1) were giant-sized, 46.0 kg.

Regarding the intercanine distance, the mean for the maxilla for the whole animal sample (n = 50) was 35.3 mm, with a standard deviation of 7.9 and for the mandible it was 30.6 mm, with a standard deviation of 5.6. The lowest values found were 22.0 mm in the maxilla and 18.0 mm in the mandible (of the same dog), which weighed 6.1 kg (small). The highest values were 65.3 mm in the maxilla and 45.1 mm in the mandible (of the same dog), which weighed 46.0Kg (giant). The dog sample with the lowest weight (4.9 kg) had an intercanine distance of 30.0 mm in the maxilla and 25.4 mm in the mandible.
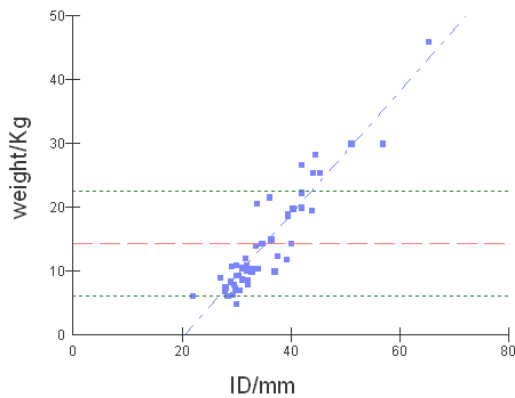
Table 1: Distribution of the sample of dogs according to the frequency, percentage and means of weight and intercanine distances in the maxilla and mandible.

Dogs				Means		
Size	Weight/ kg	#	%	Weight / kg	Intercanine distance / mm	
					maxilla	mandible
Small	<9.0	14	28	7.3	29.0	25.5
Med	>9.1-23.0	29	58	13.8	34.9	30.7
Large	>23.1-40.0	6	12	27.6	47.2	39.7
Giant	>40.1	1	2	46	65.3	45.1

Fig. 3: *Correlation between body weight (dog) and intercanine distance in the maxilla.*

When we consider the stratification of the sample per weight, the means that were found for the intercanine distance in the maxilla and mandible, respectively, were 29.0 mm and 25.6 mm for small dogs, 34.9 mm and 30.7 mm for medium dogs, 47.2 mm and 39.7 mm for large dogs, and 65.3 mm and 45.1 mm for giant dogs (Table 1).
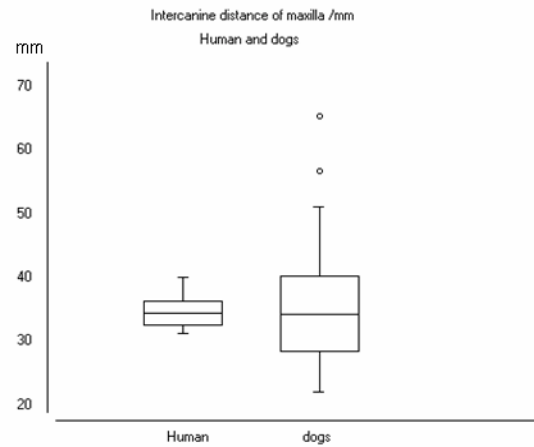

Fig. 4: *Intercanine distance of maxilla/mm of the sample (human and dogs).*

A correlation (*Pearson*) was found between the animal's weight and the intercanine distance (ID) for both the maxilla (r = 0.93) and the mandible (r = 0.83). Figure 3 shows this correlation between weight and maxillary intercanine distance. The descriptive statistical analysis for the human sample revealed that the mean intercanine distance for the maxilla in the entire sample (n = 50) was 34.3 mm with a standard deviation of 1.8 and in the mandible this mean was 27.5 mm with a standard deviation of 1.7. The lowest values were 31.2 mm in the maxilla and 25.0 mm in the mandible.
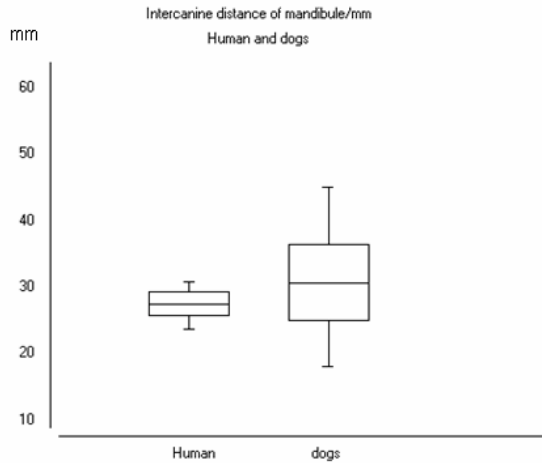
Fig. 5: *Intercanine distance of mandible/mm of the sample (human and dogs).*

Figures 4 and 5 present the values for intercanine distances in the maxilla and mandible of the entire sample (human and dogs) and it is possible to see that the measurements are concentrated between the values of 25 and 35 mm. The differences between the mean IDs in the maxilla and the mandible found in human subjects and dogs varied with the size of the animal; the smallest difference was found in the comparison with medium-sized animals. For animals of this size, distances were 1.7% higher in the maxilla and 10.4% in the mandible (Table 2). The ID results for the sample of dogs (n = 50) suggest a difference of 2.8% higher for the upper arch and 10.4% for the lower arch when compared with human intercanine distances (a reference mean in this study of 34.3 mm for the maxilla and 27.5 mm in the mandible).

Table 2: *Difference in mean intercanine distances in the maxilla and mandible between medium-sized dogs and humans.*

	Medium-sized dogs	Humans	Difference means / mm	% ≠
ID maxilla / mm	34.9	34.3	0.6	1.7
ID mandible / mm	30.7	27.5	3.2	10.4

DISCUSSION

Forensic literature has shown that both domestic dogs and humans can produce bite wounds and the identification of the aggressor is the determining factor in subsequent investigations. In order to direct the investigations into bite marks one attempts to observe if the dimensions and configuration of the lesion allow an identification of whether they were produced by humans or animals, and the intercanine distance is one of the parameters that is used by several authors. [2,3,5,7-9,11,12,14,16] It is important to note that humans have four incisors per dental arch, while dogs have six. However, the marks left behind do not always show the full arch and the distortions produced by the elasticity and retractility of tissues, movement and amount of contact can lead to misinterpretation.

If one only considers the morphology and anatomy of the teeth of dogs and humans, there would certainly be no difficulty in differentiating the markings produced by the two species as distinct. But given the dynamics imposed during the biting act and the reaction of the victim, what is observed is not a simple impression of teeth on a substrate. Where the biting injury quality allows the identification of puncturing lesions, suggestive of penetration of canine teeth, the distance between these marks is measured in an attempt to work out to which species they belong.

The results of this study show a correlation between the intercanine distance and weight of domestic dogs and a greater weight implies a larger animal. However, the sample size did not allow us to indicate the existence of maximum and minimum values, especially because the variance was significant. The measurements taken in this human sample are within the range published by the American Academy of Pediatrics[12] and the mean for the maxilla was 14% and for the mandible 2.9% higher than those found by Marques et al[5] also in a sample of Brazilians. However the human sample in our study was not standardized. It is noteworthy, however, that for medium-sized animals (over 9.1 kg and up to 23.0 kg), we obtained values closest to those in the human sample, with values that were only 1.7% greater for the maxilla. The analysis of these distances alone

would not differentiate whether the offending agent was animal or human.

CONCLUSIONS

The intercanine distance of both the maxilla and the mandible in dogs is related to the animal's weight, however, the size and shape of skull related to the breed of the animal must be considered in future studies. The variability of the intercanine measurements found in both humans and domestic dogs had similar values, but on average measurements for the dogs are larger. Intercanine distances measuring between 25.0mm to 35.0mm were found in both humans and different sizes of the canine species. These differences are also suggestive of significant individual variation, which may help identify the biter, and distinguish the impression left by the bite. We understand that the intercanine distance when found and measured in bite marks (on its own) does not allow a conclusive analysis in determining the origin: animal or human, especially when measurements for medium sized dogs, as in this study, are similar to the overall results for humans. Therefore, further studies should be carried out, in an attempt to clarify the origin and differentiation of biting injuries.

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